ART. VI.—*Modern Fireproof and Watertight Building Materials.—Traegerwellblech and Asphalt.*

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MR. PRESIDENT AND GENTLEMEN—

The subject of the paper which I have the honour to offer for your consideration this evening must be viewed from two standpoints.

The first has in view the anomaly which is apparent in the manner in which large warehouses are being carried out around us. With massive walls of masonry, which give to the exterior a stately and noble appearance, the interiors are fitted up with staircases, floorings, and partition walls of the most combustible materials. The question of insurance alone is thus affected in a marked degree.

The second involves the consideration of sanitary measures and precautions against the insidious influence of damp.

Actuated by a conviction that these matters merit the most earnest consideration, I shall now proceed to describe, from diagrams and other suitable illustrations, some building materials of comparatively recent invention, which I have reason to believe are not yet before the public in this part of the world, and which, I hope to convince you, fulfil all the requirements calculated to bring about a desirable and much-needed reform in the whole art and process of building.

The building material I shall speak first about is of a very ingenious character; it is fireproof, and a covering and bearing material at the same time. I shall use further on its German name,

TRAEGERWELLBLECH,

which means a bearing corrugated-iron plate. Traegerwellblech was first used in Belgium as a material for bridge plates, but having only very flat corrugations its bearing strength was in no proportion to its price. The material now known on the Continent of Europe under the name of Traegerwellblech is an invention of Messrs. Hein, Lehmann and Co., of Berlin, who succeeded in inventing a machine which corrugates the iron plates in a cold state. Those drawings by which I shall explain the application of this material are partly copies of designs of Mr. A. Lehmann, partly designed by myself.

As you see from Fig. 1, Traegerwellblech is a corrugated-iron plate, of which the corrugations possess the characteristic of being greater in depth than in width, and whereby each corrugation is formed by perpendicular pieces with semicircular undulations, so that the whole forms a connected series of semicircular curvatures, connected by the intervening iron beams. Traegerwellblech thus represents all the essential features for withstanding a load, since it offers the greatest moment of resistance with a minimum of dead-weight. Subsequent to the conflagration of the Kaiserhof Hotel, in Berlin, in 1875, Traegerwellblech was largely used in the process of restoration for the landings, staircases, corridors, and partition walls, especially in lieu of brick arching between iron girders, which, on account of unequalised expansion, had ill withstood the effects of fire, and collapsed.

The *Zeitschrift für Bauwesen*, the leading German journal for architecture and civil engineering, issued by the Minister of Public Works, expresses itself as follows (page 169, year 1877):—"The opportunity thus afforded for exhibiting Traegerwellblech in the dual character as a fireproof medium and as a bearing construction for the massive walls, seems to point to the probability of the usefulness of this material to purposes in the architectural constructions, and its application can be highly recommended," and further on calls particular attention to the state of brickwork arching between iron girders. "The flat brickwork arching between iron girders withstood the fire badly; the unyielding bonding of the bricks became detached from the expanding iron beams, the collapsing material, meeting with no resistance, fell in, and the vaulted spaces were thus deprived of all protection from fire."

Traegerwellblech plates are made in lengths up to 15 feet, the breadth varying from 1 foot 6 inches to 2 feet 2 inches; the thickness of the iron is between one and five millimeters. (19—10 B.W.G.)

The curvilinear Traegerwellblech plates are more advantageous than the straight ones in this respect, that they are capable of withstanding eight times the load of the latter.

The curved Traegerwellblech plate rests on the lower flange of the girder, the supported ends are walled up, the whole is then filled with ashes, sand, or clay, and levelled over, and the floor laid down, which may be composed of cement, asphalt, brick, or wood.

A ceiling of Traegerwellblech, straight or arched, is not only in conformity with all the exigencies demanded for this part of an architectural structure, but it leads to the construction itself of ceilings to the highest degree of perfection. It is light; it is a bearing and space-covering construction at the same time; it requires very little height, by which the walls can be lower and therefore cheaper; it is fireproof, and can be used to ventilate ceiling and rooms. Compared with wooden ceilings, it is cheaper by its durability; it is absolutely cheaper than brick arched ceilings, for which it is the most reasonable substitute in all buildings where the by-laws require a fireproof covering of rooms.

These four drawings (Figs. 2—5) will explain the different kinds of Traegerwellblech ceilings which have been carried out in factories and private buildings.

A further adaptation of Traegerwellblech is to be found in fireproof staircases. The plates are laid in inclined planes from one landing to another, the risers are formed up with brick, and the treads are finished off with wood. For wood may be substituted marble slabs, as, in certain instances, has been the case. This drawing (Fig. 6) will give a good idea of such a Traegerwellblech staircase.

For fireproof curtains in theatres the Traegerwellblech is the only material which satisfies all the conditions requisite to establish it as a truly reliable safeguard against fire, by which Traegerwellblech curtains, moved by hydraulic pressure, are now applied to all the important theatres in Germany. Mr. Seipp, of Berlin, who has devoted much time and study to this matter, constructs these curtains as shown by Fig. 7.

The stronger Traegerwellblech plates, that is to say, those of 11, 10, 9 B.W.G., have been most profitably employed as bridge plates.

Figs. 8, 9, and 10 show the construction of Traegerwellblech roofs. The remarkable feature of these roofs and domes is their being free from any rafters and purlins; only tierods are required if the walls be not strong enough to resist the horizontal thrust. The vertical iron you see in the plan is mere thin hoop iron to keep the tierod in a horizontal position. Such roofs have been carried out up to a span of one hundred and twenty feet. They have a parabolic form; the rise is generally one-fifth of the span, and they are provided with louvres in intervals of three or five feet. For small spans up to twenty-five feet our light Colonial corrugated-iron roofs are cheaper than these Traegerwellblech roofs; but for roofs over factories, or railway stations with large span, they are highly to be recommended.

As far as I am aware, the Dutch Government has ordered gatekeeper cottages of Traegerwellblech for their colonies. Considering that such cottages would stand a bush fire, especially if covered with stone-paper outside, which would also make a good ventilated cool wall, it should be worth while trying such cottages for our country stations.

All Traegerwellblech plates are either varnished or zinc-coated, not galvanised.

Messrs. Palmer, Scott and Co., who are the agents of the manufacturers, Hein, Lehmann and Co., and Mr. Mephan Ferguson, who has acquired the right to carry out all constructions of Traegerwellblech in Victoria, have kindly sent specimens of this material for your inspection.

I shall now proceed to the second part of my paper, to

Watertight Building Materials.

I use this term advisedly, since I am aware that it is apt to sound somewhat strangely to English ears. It has been adopted, however, after mature deliberation, by the profession, and signifies absolute imperviousness to moisture.

I shall not, on this occasion, refer to the pernicious influences of damp dwellings, nor shall I enlarge on the waste of capital in the multiplication of ill-considered and defective structures. Suffice it for me to enumerate the several quarters from which buildings are exposed to the attacks of moisture :—

1. Rain, and consequent percolation from above;
2. Absorption from the atmosphere, consequent on the hygroscopic innate qualities of the material employed;
3. Absorption from below the surface of the ground.

Various devices have been resorted to, and many are the substances that have been put to the test in repeated attempts to solve the problem of protecting buildings against the inroads of moisture from the three sources I have named; notably among them are copper, lead, zinc, iron, glass, cement, and asphalt. From among these asphalt, with various combinations of other substances, has proved hitherto the best protection; and I may note, in passing, that, not to mention other firms, that of Messrs. Büsscher and Hoffmann have made the manufacture of watertight building materials of asphalt a speciality.

The advantages possessed by this latter material are, briefly, these :—

1. Asphalt is not absorbent, and capable of resisting the action of water in so far as our present purpose is concerned.

2. Its elasticity and homogeneity renders it capable of being laid in successive layers, like a diaphragm over irregular surfaces.

3. Notwithstanding its ready adaptability to combine with almost every known building material, experience proves that no danger of disintegration is to be apprehended from differences in expansion and contraction in the mass protected by this medium.

The following are the several varieties of this form of asphalt as at present prepared for building purposes :—

Carbon de pierre (stone pasteboard);
Asphalt felt;
Asphalt plates;
Asphalt bricks.

The material called carbon de pierre, stone-paper, or stone pasteboard (German, Steinpappe), was invented by Dr. Faxe, a gentleman of the Swedish Navy, who flourished in the last century. During the first half of the present century, Dr. Gully, an eminent Prussian engineer, and Mr. Büsscher, the father of the proprietor of the factory I have made mention of, made that material a subject of earnest study in Sweden and Finland, and eventually matured the project for its manufacture in Germany.

The carbon de pierre is used in the following manner :— To the purlins are spiked boards, and upon these boards, in distances of 3 feet 4 inches, are nailed battens of triangular section—thus △; the intervening spaces between these battens are laid with separate sheets, the edges of which lie against the sides. The continuity of the covering is effected by securing strips of the same material over these divisions in the manner indicated, and finally the whole is treated with asphalt in a fluid state.

A quite modern construction is the wood-cement roof. The purlins have only a slope of 1 foot to 25 feet; they are covered with boards well-tongued and grooved. Over the boards is sieved sand ¼-inch thick, then follow three layers of paper. This is a sample piece, each layer brushed carefully with fluid asphalt. After this being done, the whole area of roof is filled in, 6, 12, and more inches, with coarse gravel and good soil on top.

Fig. 11.—Here are given delineations of the various roofs in vogue—brick roof, slate roof, corrugated-iron roof, and stone-paper roof. You will observe that, apart from the moderate cost of the latter, a considerable further saving is effected on account of the low pitch which this material renders possible.

Fig. 12 shows the stone-paper roof as adapted to sheds. Should exception be taken to its dark colour, I may mention that this might be varied to any extent by treating with ordinary lime-wash.

Fig. 13 represents the so-called wood-cement roof, applied to private residences and to warehouses. In the former it permits of a perfectly flat roof, which can be utilised as a flower garden, whereby the charms of the hanging gardens of Semiramis, so celebrated in ancient history, may be enjoyed at the present day; also, and especially in the latter case, the entire enclosed space is available for the storage of goods and for other rooms. That these rooms are fireproof, with regard to fire in the neighbourhood, is to be taken for granted. If, instead of wooden joists and boards, iron girders on curved corrugated iron be employed, as has been done for the roofs of the Imperial Printery in Berlin, this kind of roof may be considered absolutely fireproof.

The asphalt felt has its origin in England. It is produced from cotton and other textile waste with an admixture of pitch in a fluid state. It has not proved particularly successful, and its application seems to be limited to the securing of ridges and for the preliminary coverings of roofs.

Asphalt plates consist of layers of asphalt alternated with laminæ of some coarse fibrous materials. This combination was known to the ancient Egyptians and Babylonians. It fell into desuetude, however, with many other arts and inventions, and has only been resuscitated forty years ago. Referring to our illustrations, Fig. 14 gives two different modes of uniting the asphalt plates; in most instances the method x will be found to suffice. The plates generally have a length of 12 feet, a width of 2 feet 8 inches, and a thickness of $\frac{1}{4}$ to $\frac{1}{2}$ inch. The overlapping joints are firmly united by means of asphalt in the fluid form, and the entire exterior surface is treated in the manner previously indicated.

Fig. 15 shows a method of applying the plates in order to get dry rooms in fortifications.

Fig. 16 shows a section trough and a portion of a bridge. I cannot restrain, in passing, from making a brief reference to the great necessity of protecting the bearing surfaces of these important and costly structures from the effects produced in many ways from the penetration of water.

Fig. 17 shows in what manner a cottage in a low-lying locality may be insulated from moisture.

Fig. 18 shows a brick-kiln protected in like manner. This insulation is very important in this case, in order to get well-burned bricks.

Fig. 19 shows in which way any foundation may be protected by the interposition of a substratum of this invaluable material.

Fig. 20 depicts the roof of a cotton factory made of the asphalt plates as a precaution against fire. The entire roof-area forms a permanent water reservoir. Should fire arise in any part of the building, the quenching of it is palpably a matter of instantaneous accomplishment.

Asphalt bricks.—This item may be dismissed with the remark that, with the exception of watercourses and fortifications, asphalt bricks meet with little favour. The cost of freight will prohibit their use here, and I much doubt their ever attaining to any marked degree of popularity, although they could be employed with great advantage for grain stores.

Having thus brought the functions of two new and genuine kinds of building materials under review, I trust to have awakened sufficient interest in your minds to encourage their introduction in this town. Investors have a right to expect that the best available known means shall be adopted to ensure a dry and fireproof building; and the community in general have a right to demand the framing of such by-laws as shall bring about a radical change in the present mischievous system in force of running up dwelling-houses which, from their great susceptibility to damp, are the source of many dreadful diseases.

In support of the theory here advanced I may, in conclusion, aptly quote the opinion of an eminent English authority. Mr. Chadwick, Commissioner of the International Exhibition at Paris, in a report to the British Government thus expresses himself:—"There is yet another reason why the construction of walls in common brick or soft stone should be abandoned, namely, from the facility with which these materials absorb and retain moisture. The brick ordinarily in use in England is capable of absorbing 1 lb. weight of water. Thus a small cottage having walls one brick in thickness will be composed of about 12,000 bricks. These afford the united capacity of absorbing 1500 gallons, equal to 6000 quarts or $6\frac{1}{2}$ tons of water, which in its turn will require 3 tons full measure of fuel to evaporate."

As it will be impossible to abandon bricks altogether in favour of concrete buildings, which Mr. Chadwick has in view, we should at least employ methods by which the dangers of dampness can be either prevented or reduced to a minimum.

APPENDIX.

In order to make this paper more useful for the professional Engineer and Architect, I thought it advisable to add a table of the bearing strength of the various Traegerwellblech plates now in use.

The tests, of which the following data are the results, were carried out under the superintendence of Royal Engineers and Architects in Berlin.

I. Bridge Plate.

Plate No. 14, 3 feet long, tested by hydraulic pressure.

$22\frac{1}{2}$	tons	caused a bending of	3″
$28\frac{1}{2}$	,,	,, ,,	$5\frac{1}{2}$″
29	,,	,, breaking.	

II. Flooring Plate.

A curved Traegerwellblech plate, No. 2, 11 feet span, 1′ 2″ rise. The plate broke when loaden with 2800 lbs. of pig iron per superficial foot.